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Final Report

F-A2293

UNIVERSAL CODE FOR GENERAL PHOTOGRAMMETRIC PROBLEM

by

Charles A. Moench

April 8, 1959 to May 1, 1963

Prepared for

ABERDEEN PROVING GROUND

Contract No. DA-36-034-509-ORD-24RD

Department of the Army Project No. TD 3-03538

THE FRANKLIN INSTITUTE

LABORATORIES FOR RESEARCH AND DEVELOPMENT

PHILADELPHIA PENNSYLVANIA

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TABLE OF CONTENTS

INTRODUCTION

As conceived and defined in this contract, The Franklin Institute launched an effort to develop a universal computer code for expressing the solution of the General Photogrammetry Problem.

Initially, the primary aim was a total familiarity with the Photogrammetric problem and the state of the art for solving it. The most recent techniques were to be found in the paper, "Eine Analytische Lösung fur die Aufgabe der Photogrammetrie" by Dr. Hellmut Schmid of Ballistic Research Laboratories. The method of solution as described therein was the method to be used in the final code.

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OPERATION AND RESULT

Working in close liaison with Dr. Schmid, our technical advisor, an outline of our goals was established while this staff familiarized itself with the problem. It was recognized early in this relationship that considerable effort would be required in translating the theoretical solution, described in the above paper, to a numerical solution with the usual encumbent limitations inherent in all computer systems. Following an initial period of study, the first step toward the solution of the General Problem was the computerizing of a very specialized one, the solution of the single camera problem.

While Dr. Schmid's staff performed hand, desk and computer computations, ultimately accumulating all steps into one computer program, this staff initiated the second phase, writing a program for Univac I, our in-house facility, to solve the single camera problem. Many questions posed in the original efforts were answered or in some way simplified in these first phases. To list a few,

a. The problem and its detailed solution were fully understood

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b. Initial techniques, as described in Technical Memo #1 (See P-A2293-2; May, 1959) were correct

c. Summary details of the theory provided in a supplementary document by Dr. Schmid further simplified computerization

d. The solution of the single camera problem on two computers (that at Ballistics Research Laboratories and our Univac I) differed decimally in only that portion of the solution beyond the measuring accuracy of the data supplied to compute the solutions

e. The theoretical error criteria could be met numerically

f. Portions of this program could be generalized and incorporated into subsequent programs

g. This program could find immediate use by the Photogrammetry Section at Army Map Service.

Concurrent with this effort, the concepts of universal code were being investigated more thoroughly.

Initially, it was proposed by the contractor to develop an entire coding system whose pseudo-code would be tailored specifically to the kind of operations encountered in the general problem of photogrammetry. One would use this

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pseudo-code with relative ease in writing a program to solve a specific photogrammetry problem. Moreover, the translation of this pseudo-coded problem into the basic machine language of "any" machine would be feasible. In fact, it was proposed by the contractor to develop such a translator for the Univac I. This was the original concept of the Universal Code.

However, all these things do not necessarily make a universal code. A code becomes truly universal if, and only if, it is accepted universally by users of computers. It became increasingly evident that to pursue the original concept of the Universal Code would very likely have led to a gross waste of effort; what The Franklin Institute conceived as a good common denominator for present and future machines may very well have been rejected by a large portion of the industry. This would have been particularly true since The Franklin Institute's concept would, of necessity, be influenced by the nature of the photogrammetric problem. Hence, having developed what might be termed a "Universal Code," The Franklin Institute would then be faced with the awesome task of convincing the rest of the computer world that translators

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for many machines must be developed so that the photogrammetry problem may be solved on a variety of machines. The probability of success seemed quite small.

Attention was turned, therefore, to ALGOL the Algebraic Oriented Language under development by the joint effort of the ACM and GAMM (Association for Computing Machinery and The Association for Applied Mathematics and Mechanics, Germany). This is a language which is universal in nature because many computer manufacturers had committed themselves to its design and to the development of compilers for it. It is, perhaps, far more general in essence than is needed for the problem of photogrammetry. Nevertheless, the ultimate objective, to be able to use any machine for solving a photogrammetric problem, seems well within reason if ALGOL is used as a pseudo-code.

The major disadvantage to using ALGOL as a Universal Code for photogrammetry was that while computer manufacturers may in good faith intend to develop compilers for ALGOL, nevertheless, such compilers did not yet exist. Indeed, the ground rules for the pseudo-code have not yet been completely settled on. Consequently, it was impossible to determine

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when an ALGOL coded photogrammetry problem would have become an actual machine code for some particular machine.

For that reason, consideration was given to a pseudo-code which, though not generally referred to as universal, was in fact more nearly universal at the time than any other code. That code was FORTRAN.

Although the name FORTRAN is attributed to one major manufacturer, all major manufacturers and many smaller ones have recognized the universal acceptance of this language to express the solution of mathematical problems, and, although some choose to call FORTRAN by another name (such as AUTOMATH 800) they have implemented compilers to translate this pseudo-code into machine instructions. It may be further noted that the impact of nationally produced computer equipment on foreign markets has pressured some foreign manufacturers into producing compilers to accept this language.

At the conclusion of writing a program for Univac I to solve the Single Camera Problem and the subsequent accuracy checking by Dr. Schmid and his staff, a manual of operating procedures was written to accompany it. The Manual, "A Routine to Solve the Single Photogrammetric Camera Problem on Univac,"

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(See P-A2293-15; June, 1960) was delivered to Army Map Service accompanying the computer program. They have confirmed, in field test, the adequacy of the system under actual working conditions.

The flow charts issued as a supplement (See P-A2293-23; February, 1961) to describe the procedure used in programming the solution of the single camera problem, also provided to Dr. Schmid and Army Map Service, was utilized in developing the universal code — the FORTRAN version of this program.

To accompany the program, a Manual, "A FORTRAN Routine to Solve the Single Photogrammetric Camera Problem," (See P-A2293-32; November, 1961) was produced. In addition to the operating instruction to utilize the program, the Manual also included the statement listing of the program. This feature would enable any user in possession of the Manual to reproduce the "source deck," the list of statements used in expressing the solution.

Experience gained in this first FORTRAN effort served to further strengthen the argument for utilizing a manufacturer's sponsored universal code. The need for infinitesimal care in its preparation, the time and man power spent by these

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various groups, even with their first hand knowledge of the equipment, the compilers remain in constant state of change. The rules for using the code were sufficiently defined to use them for this problem. Yet the failure of small details in developing the compilers were overlooked until a problem of this length and complexity tested its ability to produce an operational machine language program.

As mentioned previously, all of our work was being done in close liaison with Dr. Schmid. In the course of translation from a theoretical to a numerical solution, several areas in the original report were modified or required redefinition, and consequent modification of the program under development.

While computerizing the single camera problem, Dr. Schmid provided a supplementary paper to detail solving the problem of two photogrammetric cameras. This represented the skeleton for solution of the General Photogrammetric Problem. Only minor modifications and computer size and speed would hinder the generalization.

A procedure similar to that used in this first phase was followed in developing this program. The program was written for Univac I. The solutions of test cases were

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compared with those computed by Dr. Schmid's staff and again the degree of accuracy required was satisfactory. An operating Manual and accompanying flow charts, descriptive of use and techniques, entitled, "A Routine for Solving the Problem of Two Photogrammetric Cameras on Univac I" (See P-A2293-36; March 1962) was prepared. The program and Manual, like those for the single camera problem, found immediate use by the Photogrammetry staff at Army Map Service.

In the course of writing the FORTRAN program to solve the two camera problem, efforts were interrupted to check and debug a special FORTRAN program in connection with Project ANNA. Making use of a portion of the computer solution of the single camera problem, the program, with additional data, computed the Aximuth, Zenith Distance, Right Ascension and Declination of selected points descriptive of a satellite position. The program test data, their corresponding solutions, and other pertinent information were returned to Dr. Schmid.

Efforts were again returned to the universal expression of the solution of the two camera problem. Many of the new innovations incorporated in later versions of FORTRAN or

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FORTRAN-like languages were utilized in the program. With reference to average FORTRAN program size, this program is classed as an extensive effort using this language. Normally, the program would require one of the largest of the present generation of computers available. But with the newer version of FORTRAN, a user could adapt the program to operate on a smaller scale machine.

As with all programs developed, a Manual was prepared to document this program and its use. Entitled "A FORTRAN Routine for Solving the Problem of Two Photogrammetric Cameras," (See P-A2293-42; September, 1962) numerous copies were delivered to Dr. Schmid, and one to Army Map Service for their immediate use.

CONCLUSION

Conforming to the plan layed out at the beginning of this task, the subsequent steps in this developmental area would have been programs to solve the five camera problem, the strip and block problems. However, changes made known to us in the latter stage of the latest amended contractual period indicated major modifications would be required in all programs developed from the beginning. As a consequence, our efforts terminated in the early phases of developing the universal expression of the five camera problem.

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- Continued -

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